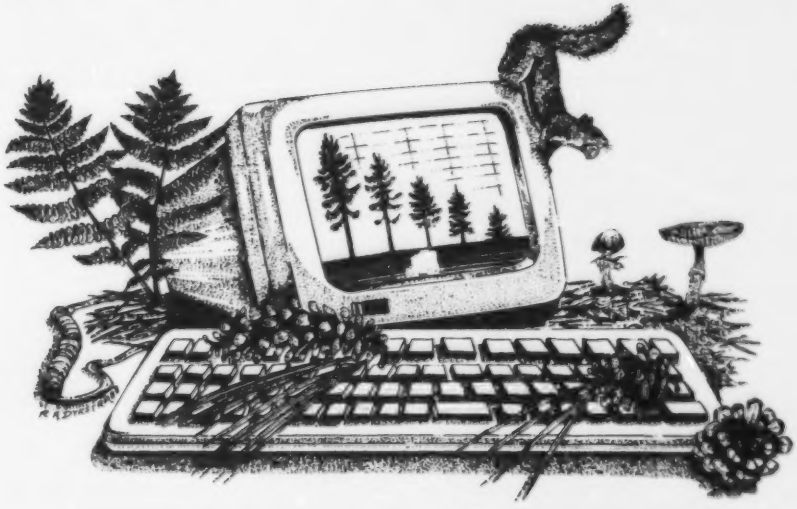
Forestry Canada Forêts Canada

PNFI PROGRAM REVIEW 87-88



PETAWAWA NATIONAL FORESTRY INSTITUTE

89-01441/

PETAWAWA NATIONAL FORESTRY INSTITUTE

PROGRAM REVIEW

1987-1988

PETAWAWA NATIONAL FORESTRY INSTITUTE
CANADIAN FORESTRY SERVICE
CHALK RIVER, ONTARIO

©Minister of Supply and Services Canada 1988
Catalogue No. Fo41-4/1988E
ISBN 0-662-16580-2
ISSN 0710-4251
Printed in Canada

Copies of this publication may be obtained free of charge from the following address:

Publications Distribution Centre
Petawawa National Forestry Institute
Chalk River, Ontario
K0J 1J0

Telephone: 613-589-2880

A microfiche edition of this publication may be purchased from:

Micromedia Ltd.
Place du Portage
165, Hôtel-de-Ville
Hull, Québec
J8X 3X2

Cette publication est également disponible en français sous le titre
Revue du programme 1987-1988.

THE CANADIAN FORESTRY SERVICE

The Canadian Forestry Service is the main focus for forestry matters in the federal government. It provides national leadership through the development, coordination, and implementation of federal policies and programs to enhance long-term economic, social, and environmental benefits to Canadians from the forest sector.

The service is a decentralized organization with six regional forestry centres, two national research institutes, and seven regional sub-offices located across Canada. Headquarters is located in the National Capital Region, in Hull, Québec.

In support of its mandate, the Canadian Forestry Service carries out the following activities:

Administers forest development agreements negotiated with the provinces

Undertakes and supports research, development, and technology transfer in forest management and utilization

Compiles, analyzes, and disseminates information about national and international forest resources and related matters

Monitors disease and insect pests in Canada's forests

Provides information, analyses, and policy advice on economics, industry, markets, and trade related to the forest sector

Promotes employment, education, and training opportunities in the forest sector

Promotes public awareness of all aspects of the forest sector

The service interacts regularly with provincial and territorial governments, industry, labour, universities, conservationists, and the public through such bodies as the Canadian Council of Forest Ministers, the Forest Sector Advisory Council, the Forestry Research Advisory Council of Canada, the Canadian Forest Inventory Committee, the Canadian Committee on Forest Fire Management, the Canadian Interagency Forest Fire Centre, and regional consultative committees. The service is also active in international forestry agencies such as the International Union of Forest Research Organizations and the Food and Agriculture Organization, as well as in technical and trade missions.

Table of Contents

Preface ..... *vii*

Forest Genetics and Biotechnology

Forest Meteorology 3
Tree Genetics and Breeding 5
National Tree Seed Centre, Research and Development 6
Soil Microbiology and Tree Nutrition 7
National Tree seed Centre, Seed Bank and Services 8
Molecular Genetics and Plant Tissue Culture 9
Plant Propagation 10

Technology Transfer and Operations

Fire Equipment, Products, and Methods - Development, Standards, and Evaluation 13
Special Projects and Technology Transfer 15
Public Awareness 16
Library Services 17
FIDS Technology Development 18
Petawawa Research Forest (PRF) - Forest Management 20
Forest Inventory 21
Management Services 22

Forest Management Systems

Fire Behaviour and Effects 25
Forest Fire Management Systems 27
Fire Suppression Systems 28
Silviculture and Forest Productivity 29
Digital Remote Sensing 30
Forest Management Modelling 31

Informatics

Informatics Program 35
Wordprocessing 36
Database Systems 36
Computer Systems 37
Software Services 37

Other Services

Information Services 41
Editing and Publications 43
Personnel 44
Expenditures 1987-1988 45
Scientific Contracts 1987-1988 46
Publications 1987-1988 47
Staff Listing 56
PNFI Organizational Chart 60
CFS Organizational Chart 61

PREFACE

Canadians are aware that future prosperity largely depends on our ability as a nation to use science and technology to our advantage. It is also evident that forestry will play a large role in the creation of Canada's future wealth. Prime Minister Mulroney, in his address to the National Conference on Technology and Innovation in Toronto last January, noted that we must maximize the strengths of our resource-based economy and that we must develop new industries, produce new goods, and offer new services. The Petawawa National Forestry Institute is directed to produce value-added research and to disseminate results through effective technology transfer.

To better effect technology transfer, PNFI's program has been restructured with the formation of a Technology Transfer and Operations Program. Through this program PNFI has expanded its international activities and has developed co-ventures with industry and other government agencies for development of remote sensing, fire detection, and fire suppression technologies. A proposal has been prepared by PNFI for CIDA, where the Institute will act as executing agency for Phase II of the ASEAN Tree Seed Centre in Thailand. Additionally, Institute personnel have been actively assessing the potential of national seed centres for the Southern Africa Development Coordination Conference (SADCC) countries in Africa. PNFI is still involved with the Jiagedaqi Project in China, which is committed to technology transfer of fire management systems. Several Chinese scientists have trained at the Institute over the review period. Also, as part of the Technology Transfer and Operations Program, data for the 1986 National Forest Inventory have been analyzed and prepared for publication.

The research effort at PNFI is undertaken through two principal programs: Forest Genetics and Biotechnology, and Forest Management Systems. During the review period further resources were re-directed to biotechnology research. Significant achievements have been realized with the development of somatic embryos from white spruce, red spruce, and black spruce, as well as the first ever larch somatic embryos derived from protoplasts. Another world's first was the successful culture of birch

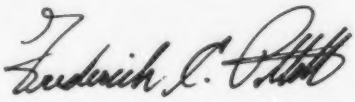
protoplast followed by callus formation. The biotechnology team hosted the IUFRO Working Group on Molecular Genetics, a sign of international recognition. Benefits of forest genetics research were realized with the selection and outplanting of PNFI black spruce clonal material on an operational scale by the Ontario Ministry of Natural Resources in Northern Ontario. Scientists at the National Tree Seed Centre, with the collaboration of the Pacific Forestry Centre, CFS-Maritimes, and the Ontario Ministry of Natural Resources, organized and presented a series of four workshops across Canada to provide provincial and industrial agencies with needed information on tree seed testing.

Advances in research and development of decision support models occurred on several fronts with expansion of expert fire management systems, development and implementation of a pest depletion estimation system, and development of several forest planning models. During 1987-88, the fire research program focused on fire prediction, with significant achievements in the completion of an integrated computation system to estimate fire behaviour, and development of the first Canadian fuel moisture model for woody components of logging slash. Enhancement of MEIS (Multispectral Electro-Optical Imaging Scanner) imagery has increased the system's capabilities for forest inventory, inventory update, and assessment of forest damage. The integration of these capabilities with Geographic Information Systems (GIS) will broaden the value to forest management in Canada.

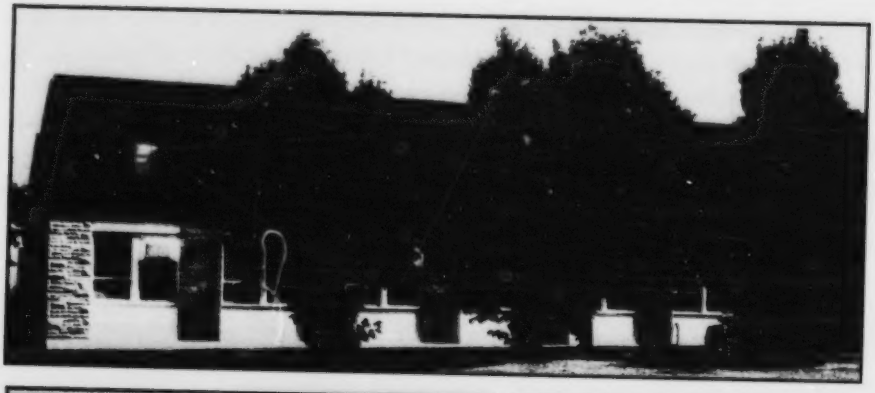
Increased emphasis on forest productivity has led to establishment of a major new study designed to develop a quantitative framework for silviculture decision-making. During the review period studies on plantation performance have spun off a prototype system that links field data collection, data summary, and analysis with a GIS for map production.

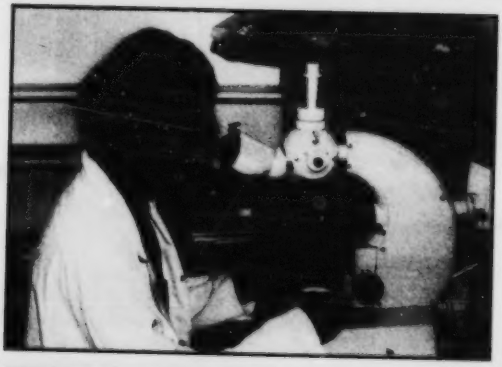
PNFI continues to be a focal point for advances in forest research and attracts visitors from all parts of Canada and from several countries. During the review period delegations from 17 countries were hosted at the Institute.

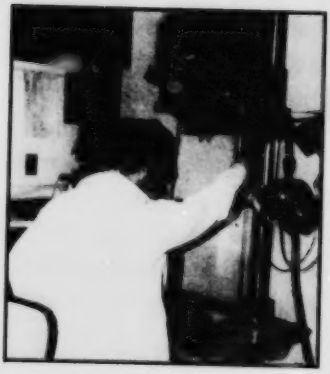
Research, such as PNFI has performed during the year under review, will enhance Canada's competitiveness in the vital forestry sector. It is essential that we stay at the leading edge of change if we are to assure prosperity for future generations of Canadians.

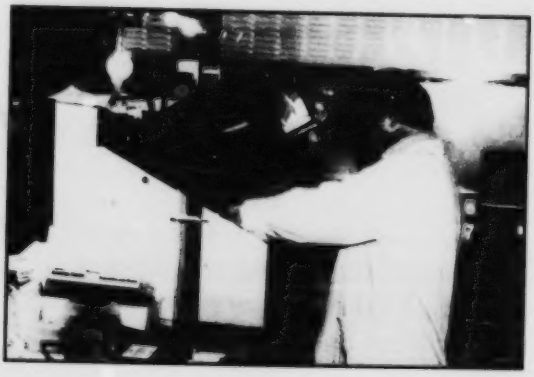


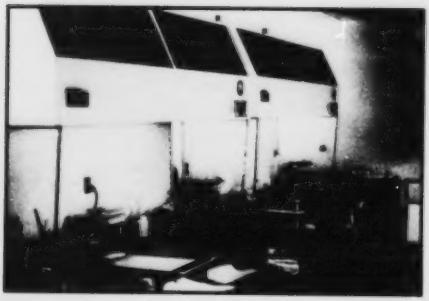
Fred C. Pollett

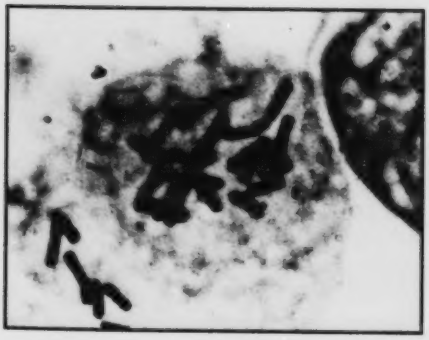


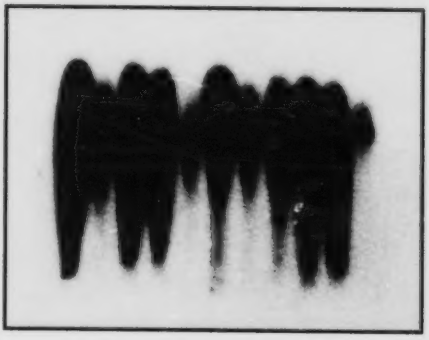












Forest Genetics and Biotechnology

PROJECT PI-8

Forest Meteorology

Objectives: Forest meteorology is the science relating weather and climate to forestry. Although meteorology impacts in major ways on virtually every branch of forestry, work in the project is being concentrated on the potentially disastrous direct and indirect effects of air pollution.

Air pollution affects the forest directly through the acidification of the soil, the leaching of minerals from foliage, and the dangerous effects of heavy metals and ozone depletion. Air pollution may have even more serious consequences through its affect upon the heat budget of the earth (the "greenhouse effect"). Present climate change scenarios predict major effects on Canada's forests caused by climate change resulting from the greenhouse effect.

The objective of PI-8 is to determine what these changes will be, their timing, and how they can be mitigated or used advantageously.

Achievements: World literature on climate change and its effects is being continously monitored. The literature on climatic impacts on certain tree species is being reviewed.

Dendroclimatological methods are being used to infer the effects of weather on species growth and survival. Present work is restricted to white spruce and red pine, but other species will be studied.

Cores are being analyzed from conifer plantations at PNFI, where competition is carefully controlled and weather is continuously monitored. On completion of the analysis of PNFI data the work will be extended to data from cores in ARNEWS studies and, ultimately, will encompass the complete range of the various species.

Advanced mathematical techniques are being applied to the data in order to support climatic effects and trends from other effects such as age

and competition. Removal of age, climatic, and insect damage effects is expected to provide evidence of possible direct effects of air pollution.

A seminar series at PNFI, bringing some of the top researchers from this continent on climate change and forestry, is ongoing.

PROJECT PI-9

Tree Genetics and Breeding

Objectives: To provide scientific leadership and know-how in quantitative genetics in order to advance breeding programs for enhanced forest renewal in northern and eastern Canada.

Achievements: Quantitative and biochemical research in the genetic architecture of black spruce, jack pine, and Norway spruce continues to yield results with implications for genetic improvement strategies.

Long-term progeny and provenance field studies across Ontario have been valuable in providing estimates of genetic variation and inheritance of growth, form, wood properties, and pest resistance.

Advanced generations of pedigreed material have been outplanted for field testing under various conditions. Improvements of young seed orchards have been accomplished by phenotypic rogueing.

A renewed effort in genetic modelling of the juvenile-mature relationship of trait expression has been initiated. Testing and development of statistical models that provide more precise and unbiased estimations of genetic parameters in field studies are ongoing.

Distribution of seed and improved pedigreed material has continued in cooperation with provincial agencies, universities, and the private industry. Information on plantation management, data handling, seed and scion collection, and pollination techniques was exchanged through extensive consultation and collaboration with clients across North America. Collaboration continued with foreign scientists and foresters, and project staff participated in seed collection in the Soviet Union.

PROJECT PI-10

National Tree Seed Centre, Research and Development

Objectives: To improve the quality, quantity, and effective use of tree seed for reforestation and tree improvement in Canada by researching and developing methods for increasing cone and seed yields and for storing, treating, and evaluating the quality of seed.

Achievements: Initial studies to define the germination requirements of black spruce and red alder under an 8 h photoperiod were concluded and additional experiments on prechilled seed started. Dr. R.K. Mittal, a visiting NSERC Fellow, concluded his studies on seed-borne fungi of white spruce and eastern white pine. The survival of black and white spruce seeds and associated fungi subjected to ultra-low cryopreservation temperatures were part of the study.

Reports on control and monitoring of cone insects and soil fertilization in white spruce plantations were prepared and published. Long-term studies on monitoring of cone and seed insects, and new investigations on their impact, will continue in cooperation with the Forest Pest Management Institute. The latter investigation is part of a new study on flowering and seed production. Experiments on flower induction in jack pine were initiated to determine the best times to apply ammonium nitrate and gibberellins in seed orchards in Ontario and Saskatchewan. This was in cooperation with Weyerhauser Canada. Experiments were also undertaken to study the optimum rates of ammonium nitrate fertilization in seed orchards, to evaluate the interaction of gibberellins, determine rates and types of nitrogen feeding, measure soil moisture levels of potted trees under polythene shelters, and to evaluate the effects of stem decapitation on the distribution of flowers in the crown.

Investigations in progress will provide opportunities for exploring factors regulating the expression of genes during flower initiation and seed development, and knowledge for developing new technologies to improve seed quality and seed production.

PROJECT PI-11

Soil Microbiology and Tree Nutrition

Objectives: To develop and assess fertilization techniques that can enhance tree growth and survival and maintain forest site productivity. Emphasis will be directed at developing improved container stock for use in forest regeneration programs through controlled nutrition, at further understanding the biology of the nitrogen-fixing alder/*Frankia* symbiosis, and assessing the impact of interplanting of nitrogen-fixing species on the growth of crop species.

Achievements: Considerable progress was made in improving our understanding of the alder/*Frankia* nitrogen-fixing symbiosis and in establishing field trials with cooperators. This will help assess the effect of interplanting the nitrogen-fixing system on the growth and development of crop species and on soil nitrogen turnover. Root nodule development under controlled nutrient levels was studied in detail and research is underway to understand the tripartite symbiosis among alders, *Frankia*, and ectomycorrhizal fungi. Some studies involving the effect of glyphosate on the tripartite association have been completed. Isolation of *Frankia* from soils collected from across Canada is ongoing, and methods of isolate characterization are being refined.

Seasonal trends in leaf weight and nitrogen content of 14 different hybrid poplar clones were examined. Studies of endogenous ethylene production and decomposition led to an improvement in the acetylene reduction assay for nonsymbiotic nitrogen fixation; this was applied in studies of woody residues and forest soil organic horizons. An evaluation of strategies used by six different alder species in resisting herbivory by a leaf-mining sawfly was completed.

PROJECT PI-17

National Tree Seed Centre, Seed Bank and Services

Objectives: To operate the Canadian Forestry Service Seed Bank and provide the national and international forestry community with well-documented seed for research purposes; to carry out customized seed collection, processing, and regulatory and service testing; to provide information on seed availability and the technology of seed management and storage; and, to collect and compile national seed statistics.

Achievements: A total of 125 seedlots representing 42 tree species was procured from within Canada and from five other countries. In response to 171 requests for seed, 900 samples of 129 species were distributed to clients in Canada and 14 other countries. Information on seed availability, testing, processing, and storage was sent to clients in Canada and abroad.

As an accredited laboratory of the International Seed Testing Association, referee seed testing was conducted. Service testing for clients and routine testing of seed bank material included 675 germination tests, ninety thousand seed weight determinations, 100 moisture content tests, and 10 X-rays. The extraction plant processed approximately 1120 seedlots, including complete processing from cones to seeds, recleaning, and reconditioning. Flowers and cones were collected weekly throughout the summer of 1987, and periodically in 1988, for somatic embryogenesis studies by researchers in the Molecular Genetics and Tissue Culture Project.

In cooperation with the Institute's Genetics Project staff, a five-day tree climbing course was provided to technicians of the Quebec Ministry of Energy and Natural Resources. The project staff also assisted in the organization and preparation of two CFS Tree Seed Testing Workshops held at the Institute.

PROJECT PI-18

Molecular Genetics and Plant Tissue Culture

Objectives: To research and study the new technologies of plant cell and tissue culture, molecular genetics, and genetic engineering, and evaluate their potential application in forestry using new systems of tree improvement.

Achievements: Research in plant cell and tissue culture has been successful in a number of different areas and species. Plantlets from different lines of black spruce have been successfully regenerated using micropropagation protocols. A variety of pedigreed callus and cell suspension lines of jack pine, white spruce, and hybrid poplar have been established and characterized. Embryogenic calli have been established for black, white, and red spruce, eastern white pine, and hybrid larch. Somatic embryos have also been recovered from protoplast cultures of hybrid larch.

cDNA gene libraries and genomic libraries been constructed for several conifer species, and for developmental stages during seed germination of one species. These will form the basis for a number of different studies, dealing with evolution and genome architecture using homologous nucleic acid probes and developmentally-regulated gene expression.

Using *Agrobacterium tumefaciens*, transgenic plants have been produced in many poplar hybrids. Promising results have also been obtained for a variety of conifer species. This technology will allow genetic engineering techniques to be readily applied in forestry.

PROJECT PI-60

Plant Propagation

Objectives: To operate and manage all propagation facilities at the Institute; to provide CFS projects and outside cooperators with propagated material; to provide others with advice and assistance on various aspects of plant propagation; and, to develop and improve the propagation facilities and expertise at PNFI.

Achievements: Pedigreed material was produced for research projects at the Institute as well as other outside establishments. High quality propagules were grown in modernized controlled environment facilities. They included several thousand spruce, larch, and pine grafts, tens of thousands of containerized seedlings, as well as large quantities of bare root seedlings.

A proposal for long term nursery soil management was prepared after the University of Toronto completed an extensive soil analysis. A soil fertility improvement program was initiated.

Construction of new facilities included a new propagation building with two breeding halls (500 m^2) and two new equipment storage buildings.

Technology Transfer and Operations

PROJECT PI-5

Fire Equipment, Products, and Methods – Development, Standards, and Evaluation

Objectives: To give direction to agencies and the industry for standardizing forest fire suppression methods, equipment, and products; to assess the need for and assist in the development of state-of-the-art forest fire fighting equipment; to provide a technology transfer and technical liaison service both nationally and internationally on fire suppression technology; to maintain the Forest Fire Technical Information Centre; and, to maintain the database for national statistics on forest fires.

Achievements: The national standard for external-lug couplings for forestry hose was completed, published, and assigned to the Canadian Interagency Forest Fire Centre for implementation. Proposals for a feasibility study to determine laser power requirements for an Airborne Laser Igniter were obtained. The safety certification of the "Valley Blazer" burnout torch was completed. A study to determine optimum oil/fuel mix ratios for use with Wajax Mark 3 portable forestry fire pumps was completed; an engine evaluation was also given to the company. A report was completed on the joint study with Rosscommon Equipment Center, Michigan and OMNR to determine the relative effectiveness of three categories of fire suppressants - foams, long-term retardants, and short-term retardants.

Work on several equipment specifications (hose, hand tools) progressed. The introduction of the BIFC Terratorch into both Ontario and Québec resulted in an improved system being developed by the Province of Québec.

The Project arranged a joint meeting between the US National Wildfire Coordinating Group, Fire Equipment Working Team, and the CCFFM Forest Fire Equipment Subcommittee; this was held in Abbotsford, B.C. Ongoing liaison between the two groups was established as a result of the meeting. A demonstration on fire fighting foam development and usage was given at the International WEPS Symposium held at College Station,

Tex. There was a presentation at the NWCG, Forest Fire Equipment Conference, San Diego, Ca. on the subject of Airborne Laser Ignition Systems.

Canadian Forest Fire Statistics for the years 1970–1976 and 1984–1986 inclusive are being prepared and will be published in 1988. The third edition of Smoke Signals/Signaux de Fumée was published.

Active participation continued in several organizations such as the CCFFM, Forest Fire Equipment Subcommittee, and the Canadian Standards Association.

PROJECT PI-13

Special Projects and Technology Transfer

Objectives: To identify, coordinate, and report on present, potential, and proposed technology transfer activities at PNFI; to develop a technology transfer plan for PNFI; to develop contacts and implement technology transfer priorities with various clients using innovative and effective techniques; to carry out special projects to support and enhance the management of PNFI, including planning.

Achievements: Fostering and expanding visits of technical and professional visitors to the Institute was taken as a prime means of transfer of PNFI technology to the operational sphere. Such interchange also provides the Institute with access to current problems in the national resource field and encourage research that meet these problems.

This project collaborated with Information Services (PI-22) for initial planning of the 1990 IUFRO World Conference to be held in Montreal.

Skills development and training projects were coordinated by PI-13 in collaboration with the federal department of Employment and Immigration and several other government departments. Student hiring was organized under the COSEP program.

Contacts have been developed and utilized with CPPA Forest Management Group, provincial resource management agencies, and universities and colleges.

Program planning was done by this project for the Institute.

PROJECT PI-14

Public Awareness

Objectives: To promote better management of Canada's forest resources by increasing public awareness of the forest resource and the need for it's sound, rational management through the use of interpretive educational and information projects.

Achievements: A new exhibit hall opened in 1988 at the Petawawa Forest Visitor Centre, the result of much hard work.

The on-site education project for school pupils, in formal operation since 1977, has undergone extensive evolution and revision and is currently operating successfully.

The experience of the on-site education program is being utilized in the development of a forest management education project by the OMNR and PNFI under the Canada-Ontario Forest Resource Development Agreement. Draft material will be ready for piloting in the autumn of 1988. Material thus developed will be available for adaptation by other provinces.

Involvement of the project in the planning of Silvilog '88 in St-Georges-de-Beauce, Qué. has exploited the experience gained at Silvilog '86 and increased the probability of success for the show.

The sign shop has grown to become a graphics production unit capable of producing a wide range of signage, exhibits, poster displays, illustrations, silk screens, dry transfer images, and graphics camera work.

PROJECT PI-15

Library Services

Objectives: To provide library services designed to meet the current and future information needs of all PNFI staff in fields pertinent to the objectives and work of the Institute through the selection, acquisition, organization, and dissemination of informational materials; to enhance the image of the Institute by providing library services to non-PNFI users provided this does not interfere with the quality of service given to the primary users; in collaboration with the other CFS librarians, to coordinate CFS-wide library services and develop policies in support of a national forestry collection.

Achievements: Working closely with other CFS libraries, the PNFI Library coordinated the purchase of the Sydney Library Automation System. The system was installed early in February and the cataloguing module was implemented in March. Design of the record format was accomplished in close collaboration with the GLFC/FPMI Library. The PNFI Library represents CFS libraries on the Sydney Users' Group of Ottawa-Hull.

The Library reported its serial holdings to the Union List of Scientific Serials in Canadian Libraries, and began ordering books from our agent through electronic mail. New shelving was installed and major reorganization of the shelves was completed in the serials section and in storage. The Library produced and distributed nine Library Accessions lists, a revised serials list, and three bilingual finding aids to the older CFS literature such as Silvicultural Leaflets, PS-X Information Reports, and FF-X Information Reports.

A 'Bibliography/Liste des publications pour les années 1979-1985' was compiled and published in cooperation with Editing and Publications (PI-24).

A highly active level of library service was maintained.

PROJECT PI-20

FIDS Technology Development

Objectives: To develop, manage, and provide support to new technologies such as the FIDSINFOBASE information system and the Forest Insect and Disease Survey (FIDS) Geographic Information System; to investigate new technologies that can be used in FIDS and forest pest management operations for information processing; to test and develop these new technologies; to investigate and develop applications towards survey design, pest condition analysis, and forecasting.

Achievements: The FIDSINFOBASE system was developed, upgraded, and supported by the project for use by each of the six CFS FIDS regional units. The system manages both historical and current FIDS sampling form data, insect and disease catalogues, parasite data, plot data of the Acid Rain National Early Warning System, datasets in support of pest depletion estimation, and pest impact plot data. Development continues for inclusion of other important FIDS data.

Geographic Information Systems, based on PC ARC/INFO software, were installed at three regional FIDS units, followed by training and support. These systems are used for display of survey locations, generation of an infestation map database, and for spatial analysis of infestation with other thematic map data. A national UTM grid was generated for display of survey locations. GIS processes in map display and plotting were packaged under macro programs for ease of use.

A pest depletion estimation system was developed that uses both FIDSINFOBASE and GIS for combining infestation maps with forest inventory data, and growth loss and mortality factors. The system will be delivered to regional FIDS units for operational use in 1988.

As a part of development of decision-support systems for forest pest management, a study was begun to investigate the use of data from FIDS and other sources for pest prediction modelling. It is hoped to construct a

prediction system for the hemlock looper *Lambdina fiscellaria* in cooperation with Newfoundland authorities.

Slated for startup in 1988 is a new study for adaptation of emergent technologies to the information needs of the CFS for monitoring and evaluation of activities supported by the federal forestry development agreements.

PROJECT PI-21

Petawawa Research Forest (PRF) - Forest Management

Objectives: To integrate the management of forest resources of the PRF; to provide timber disposal and forestry services to CFB Petawawa and AECL; to enhance the understanding of forest management applications; and, to provide field services to PNFI.

Achievements: Forest management consisted of: silvicultural treatments to 156 ha using $55 540 allotted under COFRDA; monitoring forest fire activity at PNFI and CFB Petawawa; application of insect and disease control measures; and, harvesting 7 450 m^3 of timber (worth $64 000) in support of research activities.

Timber disposal from forest lands at CFB Petawawa realized 78 299 m^3, worth $687 700. A management plan was developed for the AECL property at Chalk River. This effort was funded under COFRDA.

Public awareness activities centered around Silvilog '88 in Québec, the Sugar Bush, tours of the Headquarters Silvicultural Area, and the forest. Field services activities continued to provide numerous services ranging from office moves to silvicultural and infrastructure improvement.

PROJECT PI-54

Forest Inventory

Objectives: To provide a national focus for forest inventory matters, and to facilitate at all levels the exchange and use of information and data; to develop and promote good practices and procedures for forest inventory; and, to develop, maintain, and use Canada's Forest Inventory and related information.

Achievements: The project continues participation with the Canadian Forest Inventory Committee (Member and Secretary), the CFS FORSTATS Committee (Member and Secretary), and the Canadian side of FATE (US-Canada Forest Assessment Technology Exchange - Co-Chairman, Co-Secretary, and Topic Leaders). The newsletter 'Focus on FORSTATS' continues to be published.

Cooperation has begun with Digital Remote Sensing (PI-16) to improve the application of that science to forest inventory.

The latest edition of Canada's Forest Inventory 1986 (ie. data in source inventories as of 1986) is close to completion and replaces the 1981 edition as the definitive national forest inventory. Data from this publication has already received considerable use in preparation of reports to be published and to answer client requests.

PROJECT PI-31

Management Services

Objectives: To provide an administrative control system and fiscal accountability in accordance with statutory and regulatory requirements; to provide general administrative services including purchasing and matériel management, records management, accommodation services, office services, and fleet management; to operate and maintain the physical plant; to manage PNFI construction projects.

Achievements: The physical plant at PNFI includes buildings constructed over six decades. New construction and several renovations were undertaken during the review period to expand wet laboratory facilities, and create new propagation facilities and more office space. A Master Plan for a phase upgrading of the entire physical plant has been completed and will be used to construct better research facilities. While awaiting approval of the Master Plan, funds have been obtained for minor construction to upgrade facilities for the forest genetics and biotechnology project. As well, there has been an upgrading of the physical plant, inlcuding projects such as road and bridge construction, new nursery breeding hall facilities, and mechanical and electrical upgrading.

Installation of computerized tracking systems has improved stores operations. The motor vehicle garage is now supplied with modern instrumentation for engine analysis.

The residential section of PNFI was refurbished; more upgrading is planned this year with the introduction of the new CFS distribution centre and V.I.P. visitor accommodations. Many new plant features will be installed, such as a hydro transformer system with single phase protection.

Forest Management Systems

PROJECT PI-4

Fire Behaviour and Effects

Objectives: To expand the Canadian Forest Fire Danger Rating System to yield estimates of fire spread rate and intensity in various important forest and fuel types; to apply meteorology so as to improve prediction of lightning fire occurrence; to study intense behaviour in both accidental and prescribed fires; to describe the ecological role of fire in natural forest and the basis of its use as prescribed fire in forest management; and, to develop methods of measuring the impact of fire on forest age-class distribution and timber supply.

Achievements: The main achievement in fire danger rating was the completion of an integrated computation system to estimate spread rate, extent of crowning, fuel consumption, and fire intensity. This will form the core of the forthcoming Fire Behaviour Prediction System to be entered with date, location, and components of the Fire Weather Index System. In cooperation with regional fire research staff 15 forest and slash types across Canada were covered individually. In addition, the first Canadian fuel moisture model was developed for woody components of logging slash.

In meteorological work, a study of sequences of rainless days showed that the probability of another such day depended on a varying number of previous rainless days. This number decreased in progression from about six, west of the Rocky Mountains, to one or two in eastern Canada. This result provides an intriguing basis for correlation with burned area and measures of predicted fire behaviour. A second achievement concerns the massive fire whirls often seen in large, operational prescribed fires in clear-cut slash. An analysis of data, backed up by theory, has set forth the conditions and factors governing fire whirl occurrence and is being prepared for publication.

On the biological side, the major accomplishment was an experiment linking forest floor dynamics in jack pine forest to age dated from the last fire. Turnover rates in both organic matter quantity and nutrient level were

measured, and the general conclusion was that these processes in the jack pine ecosystem are remarkably stable in their reaction to fire. Also, a cooperative study of the role of prescribed fire for site preparation in the spruce-pine forests of interior B.C. is underway, with Project staff carrying out the investigation of nutrient effects due to the various treatments.

PROJECT PI-6

Forest Fire Management Systems

Objectives: To research, develop, and integrate appropriate new decision-making, computer, artificial intelligence, and remote sensing technologies into the daily operation of Canadian fire management agencies.

Achievements: The pioneer large expert system developed by the project to despatch waterbombers and helicopter-borne fire crews was extensively revised. This complex system continues to function well at SCO in Maniwaki, Qué. and has now been installed at Thunder Bay, Ont.

Another expert system was developed during 1987 to predict the daily occurrence of forest fires caused both by humans and lightning. Human spatial perceptions of static risk were used, along with several thousand human rules, to develop a dynamic risk for each database cell. Colour graphics are used to display outputs.

The project worked jointly with the SCO and the Québec ministère de l'Énergie et des Ressources to develop a low cost infrared forest fire detection device. The work is ongoing.

Under development, as well, is an expert system for prescribed burn planning, based on procedures and experience of the B.C. Forest Service. It will assist the user through the planning process, compare objectives and likely effects, and suggest a fire weather prescription and strategy for ignition and control.

PROJECT PI-7

Fire Suppression Systems

Objective: To research and evaluate ground and aerial forest fire suppression systems and to report and advise fire management agencies on the effectiveness of such systems when used under various conditions.

Achievements: Project personnel determined the performance of the Dromader M-18 airtanker as a foam delivery system and evaluated penetration, coating, and distribution of the foam thus generated within a pine/spruce stand. The effects of mix concentration and delivery characteristics were identified. To augment field data, extensive laboratory experiments were conducted to investigate dispersion, temperature, water quality, and generation techniques on producing these low expansion foams. Rate of drainage over time was identified as the key reference characteristic. Guidance was provided to provincial agencies concerning calibration and use of the CL-215 airtanker for foam delivery.

Foam research results were used as input into the development of the NFPA Forest Fire Fighting Foam Standard and at workshops and seminars in Canada and the U.S.A. Foam research results were also applied to injection system development and/or modification.

Moisture levels in forest fuels are a prime influencing factor on ease of fire suppression; consequently, a lichen moisture code was developed to account for this fuel's volatility. This can be used when assessing hazard levels and suppression needs.

PROJECT PI-12

Silviculture and Forest Productivity

Objectives: To develop a quantitative framework for the application of silviculture in Canada, based on an improved understanding of the underlying biological mechanisms. Specific areas of research include the environmental control of plantation establishment, the evaluation of plantation performance, and the process of intraspecific competition in the development of conifer plantations.

Achievements: A major new field study, examining the effect of soil temperature, brush competition, and nutrient availability on plantation establishment, has been, commenced at three locations in Canada; Chalk River, Ont. (Great Lakes-St. Lawrence forest region), Foleyet, Ont. (Boreal forest region), and Prince George, B.C. (Sub-boreal spruce forest region). This study is supported by cooperators such as the B.C. Ministry of Forests and Lands, the Ontario Ministry of Natural Resources, E.B. Eddy Forest Products, and Northwood Pulp and Timber. Each site has a series of small plantation plots growing local spruce and pine species in an array of different environmental conditions. Plots are monitored for a variety of micrometeorological conditions, and trees from each plot are annually harvest-sampled for growth, morphology, and biochemical characteristics.

In the study of plantation performance, a prototype system has been developed that includes automated field data collection, data summary and analysis, and linkage with a Geographic Information System for map production. Several workshops and demonstrations of this system were carried out in 1987/88. Work is continuing in cooperation with Dr. Steen Magnussen (PI-9) on the production of a model of the dynamics of size distribution in even-aged forest plantations. A comparison of the growth, stem form, and yield of adjacent natural and planted jack pine was also undertaken.

PROJECT PI-16

Digital Remote Sensing

Objectives: To research, develop, and transfer to the forestry community practical methods of extracting information on the state of Canada's forests from imaging satellite and airborne sensor systems operating in the visual, infrared, and microwave parts of the spectrum.

Achievements: Effort has concentrated on development of forestry applications of linear array imager data. Forest inventory, particularly species identification, is a key area of interest. Enhancements of MEIS (Multispectral Electro-optical Imaging Scanner) imagery have given good species differentiation. Assessment of forest damage is another important application. A cooperative study with CFS-Maritimes and the Canada Centre for Remote Sensing acquired spectral reflectance data of trees damaged by the spruce budworm, and optimum sensor bands for detecting defoliation symptoms are being formulated. Design parameters for an advanced linear array imager for forestry applications have been investigated. The capabilities of a stereo MEIS imager for tree and stand height estimation is being tested.

An investigation into the capabilities of combined radar and visible infrared imagery showed the advantages of combining these data sources for species discrimination studies. Investigations into imaging spectrometers (e.g. Fluorescence Line Imager) and satellite change detection are continuing. The project operates a powerful image analysis system, and software upgrades to the system have been developed and implemented. There has been partial integration of the PNFI image analysis system with ARC/INFO Geographic Information System databases and procedures.

PROJECT PI-19

Forest Management Modelling

Objectives: To develop forest planning systems that integrate, with timber supply and allocation models, the latest technological advances in data capture by remote sensing, database management, and Geographic Information Systems; to transfer these technologies to provincial and industrial forest agencies; to undertake basic and applied research in forest mensuration.

Achievements: Development of an individual tree, distance-dependent growth model for red pine is underway. An operational test of the FIRFOR model was undertaken using inventory data for a forest management unit in northern Ontario. A new model for site index curves was developed and the production of national site index curves for white spruce is nearing completion. A comprehensive forest biomass manual was prepared. Development began of a tree classification system using MEIS datasets of the Petawawa Research Forest.

An analysis of the diameter growth of white spruce trees on the Petawawa Research Forest demonstrated a significant reduction after 1945, compared with trees of a similar age that had grown during the period 1915-1945. This difference could not be attributed solely to the effects of increased airborne pollution, and the principal factor was probably differences in competition.

Informatics

PROJECT PI-40

Informatics Program

Objectives: The Informatics Program provides PNFI research and administrative programs with software support, database support, system support, EDP consulting support, and text processing. This program provides Electronic Data Processing (EDP) and communications technical assistance, gives direction and standards for using computing technologies, and provides administrative support for Treasury Board and Departmental policies.

Achievements: The Informatics Program provided computing support to other programs at PNFI and CFS headquarters. During the past year the structure of this program was reviewed and a number of changes were implemented to better serve the needs of computer users. Further information on projects under the Program will be found under entries for PI-41, PI-42, PI-43, and PI-44.

PROJECT PI-41

Wordprocessing

Objectives: The Wordprocessing Project provides PNFI with a flexible and efficient text processing service on both the VAX computer and on AES wordprocessors.

Achievements: Wordprocessing provided text processing services for the 135 staff at PNFI, including scientists, management, and support staff. Scientific papers, meeting minutes, purchase orders, contracts, and staff performance reports were among the wide variety of documents processed.

During the past year the wordprocessing group learned to use the VAX wordprocessor available in ALLIN1 so that computer users can create documents on the VAX computer and mail them to wordprocessing for formatting.

PROJECT PI-42

Database Systems

Objectives: The Database Systems Project provides PNFI with computing service for supporting and managing the many large databases in the CFS that are kept at PNFI.

Achievements: Forty databases are kept at PNFI, including the National Forest Insect and Disease Survey, the National Forest Inventory, and the Inventory of Forest Biomass in Canada.

PROJECT PI-43

Computer Systems

Objectives: The Computer Systems Project provides PNFI with a facility for computation, information storage and retrieval, and image analysis. The project provides technical support for hardware, software, communications, and EDP security.

Achievements: Computer Systems has principal responsibility for two multi-user VAX computer systems and financial responsibility for three other VAX computers and associated equipment. This project maintains a computer network of more than 140 terminals, printers, and microcomputers, as well as two Datapac links and a Dataroute link into the CFS national communications network.

Computer Systems is examining both the computing equipment and the EDP communication systems to replace older and costly equipment and to simplify the systems.

PROJECT PI-44

Software Services

Objectives: The Software Services Project provides PNFI with general support for Geographic Information Systems, data acquisition systems, statistical analysis, graphics, data manipulation, and system analysis. This project develops applications, maintains software, and trains computer users.

Achievements: During the past year Software Services completed the loading and verification of the 1986 National Forest Inventory. Numerous applications were developed to compile, analyze, retrieve, and display the forest inventory information in tabular, graphic, and map form. A computer-based information system, based on extant inventory data, was com-

pleted as part of the Canadian Forest Resource Data System. A link between the Geographic Information System and the Regeneration Performance Survey data was designed and built. The Regeneration Survey was updated and mapped.

Other Services

PROJECT PI-22

Information Services

Objectives: To project and enhance the image of the Institute and the role of the Canadian Forestry Service to various publics; to develop, wherever possible, linkages to other agencies in and outside of the forestry sector for delivery of Institute scientific and technical programs; to manage a program of hosting visiting delegations.

Achievements: The Institute continues to receive over 20,000 visitors annually and Information Services responded to their varied needs. An increasing number of conferences and symposia, many at an international level, were successfully conducted at the Institute. Delegations visited from China, the U.S.S.R., and most western European and southeast Asian nations, as well as from throughout Canada and the U.S.A.

In 1987, the Institute conducted its biennial Open House in concert with nearby AECL/CRNL and Ontario Hydro.

Information Services responded to numerous high visibility opportunities such as developing a tri-project exhibit for the National Convention on Technology and Innovation in Toronto, which attracted an audience of industry leaders, cabinet ministers, and the Prime Minister.

The role of Secretary to the Organizing Committee of the IUFRO World Congress was undertaken and will demand nearly full time attention by Information Services personnel to sometime beyond the 1990 event. As well, the Chairmanship of the Publicity and Promotions committee has been assumed, to conceive and deliver a global campaign about the IUFRO World Congress, Canada's largest forestry meeting to date. These tasks involve constant networking with virtually every forestry agency and the forestry industry across North America.

The Institute rekindled ties with the Christmas Tree industry across Canada and the United States by overseeing a project to promote fire safety

and forest conservation messages through video news releases. A feature video show is being produced cooperatively with growers associations to promote better understanding of the industry.

Information Services coordinated and hosted a six-part television series highlighting forestry matters in the Upper Ottawa Valley.

PROJECT PI-24

Editing and Publications Services

Objectives: To publish reports and scientific papers that disseminate collected statistics and the results of research undertaken by the Institute; to promote among the general public an understanding of forest research and sound forest management by preparing and producing a newsletter, leaflets, etc. that describe the work of the Institute; to ensure that the Institute conforms to Federal bilingual requirements; to store and protect CFS national technical and scientific archives; to collate submission of CFS publications to microfiche publishers.

Achievements: A total of 81 contributions to the scientific literature were contributed by PNFI authors during fiscal year 1987-1988. These included articles in international journals, published proceedings of symposia, and PI-X series information reports in both French and English.

The purchase of a Corel Desktop Publishing System has revolutionized production of reports in that we now have instant access to sophisticated formatting capabilities and a variety of type sizes and faces. Costs have been reduced because there is no more need to use commercial typesetters.

A local printing firm has been engaged under a DSS standing offer agreement to print all PI-X series information reports. The advantages of this arrangement have included discounted printing costs, faster turnaround, and better quality. The relationship with Queen's Printer, CFB Petawawa continues.

Distribution of PNFI publications is being done through a contractor. The imminent transfer of the responsibility to distribute all CFS publications through PNFI will greatly enlarge the scope of the distribution operation. A sophisticated, semi-automated operation is envisaged.

Collation and archiving of all CFS scientific and technical documents continued.

PROJECT PI-70

Personnel

Objectives: To provide personnel generalist services to management and employees covering staffing, classification, staff relations, training, human resource management, pay and benefits, employment equity, official languages, and health and safety.

Achievements: Coordinated staffing of vacant positions throughout the year and advised managers of changes in staffing process. Hired 30 students under Challenge '87. Recommended ratings for positions, advised management in the writing of PASs, and the use of classification standards. Provided ongoing service to management and staff on staff relations, monitored new cases and precedents being set, and handled employee grievances. Assisted employees in the area of pay and benefits and implemented new dental insurance policy. Coordinated training needs of employees, developed annual training plan, and held a performance evaluation writing course for supervisory personnel.

The project participated in the PNFI Health and Safety Committee, and provided advice as required. Management and employees were advised on language identification of positions, language training, and testing. Assisted management in ensuring policies were followed by PNFI that were consistent with employment equity guidelines. A Human Resources Plan was developed for PNFI. Assistance was provided in the preparation of appraisals and monitoring of these documents to identify training needs.

PETAWAWA NATIONAL FORESTRY INSTITUTE
EXPENDITURES 1987-1988
($'000)

Program area	Person years	Salaries	Operations & maintenance	Capital	Grants & contributions	Total
Management and administration	30.5	1 047.6	1 085.0	1 408.4	–	3 541.0
Forestry data systems	10	455.5	329.8	–		785.3
Communications	9	373.4	195.4	5.1		573.9
FORSTATS	8	388.4	51.5	–		439.9
Forest management systems	43.5	1 894.3	377.3	105.0		2 376.6
Forest genetics & biotechnology	33	1 430.1	373.4	117.1		1 920.6
Total	134	5 589.3	2 412.4	1 635.6		9 637.3

SCIENTIFIC CONTRACTS OVER $5000, 1987-1988

CONTRACTOR	SCIENTIFIC AUTHORITY	PROJECT TITLE	AMOUNT
D. Lachance	Dr. L. Chatarpaul	Biochemical characterization of *Frankia* isolates.	$25 000.00
E. Mcleod	Dr. L. Chatarpaul	Nutrient analysis of alders.	6 560.00
Ragtics Consulting	Dr. L. Chatarpaul	Calibration of microcomputer version of FORCYTE-II with hybrid poplar.	20 000.00
University of Toronto	Dr. C.W. Yeatman	Photosynthetic efficiency of young, densely planted jack pine as related to the crown/stand surface area ratio.	5 000.00
University of Toronto	Dr. D. Burgess	The development of high yield willows for energy production by interspecific hybridization.	15 503.00
R.K. Mittal	Mr. B.S.P. Wang	Collection and analysis of data from experiments on seed-borne fungi.	10 999.00
P. Chakravarty	Dr. L. Chatarpaul	Evaluation of actinorhizal and mycorrhizal relationships of alders.	9 600.00

Publications 1987-1988

Ahern, F.J.; Leckie, D.G. 1987. Digital remote sensing for forestry: requirements and capabilities, today and tomorrow. Geocarto Intl. 3:43-52.

Aldred, A.H.; Alemdag, I.S. 1988. Guidelines for forest biomass inventory, Inf. Rep. PI-X-77.

Alemdag, I.S. 1987. Site index equations for white spruce in the Northwest Territories, Canada. Forest Ecol. Manage. 23:61-71.

Alemdag, I.S. 1988. A ratio method for calculating stem volume to variable merchantable limits, and associated taper equations. For. Chron. 64:18-26.

Barrett, J.W.; Cheliak, W.M.; Knowles, P.H. 1987. Variation in the PGI/AAT linkage group between populations of black spruce. Can. J. Forest Res. 17:756-758.

Barrett, J.W.; Knowles, P.; Cheliak, W.M. 1987. The mating system in a black spruce clonal seed orchard. Can. J. Forest Res. 17:379-382.

Berry, A.B. 1987. Plantation white spruce variable density volume and biomass yield tables to age 60 at the Petawawa National Forestry Institute. Inf. Rep. PI-X-71.

Berry, A.B. 1987. Tables de biomasse et de volume de peuplements d'epinettes blanches à densité variable jusqu'à 60 ans après leur plantation à l'Institut forestier national de Petawawa. Rapp. d'inf. PI-X-71F.

Bird, G.A.; Chatarpaul, L. 1988. Effect of forest harvest on decomposition and colonization of maple leaf litter by soil microarthropods. Can. J. Soil Sci. 68:29-40.

Bonnor, G.M.; Magnussen, S. 1987. Forest inventories in Canada: A framework for change. For. Chron. 63:193-198.

Bousquet, J.; Cheliak, W.M.; Lalonde, M. 1987. Allozyme variability in natural populations of green alder (*Alnus crispa*) in Quebec. Genome 29:345-352.

Bousquet, J.; Cheliak, W.M.; Lalonde, M. 1987. Genetic differentiation among 22 mature populations of green alder (*Alnus crispa*) in central Quebec. Can. J. Forest Res. 17:219-227.

Bousquet, J.; Cheliak, W.M.; Lalonde, M. 1987. Genetic diversity within and among 11 juvenile populations of green alder (*Alnus crispa*) in Canada. Physiol. Plant. 70:311-318.

Boyle, T.J.B. 1987. Future breeding strategies and the need for early testing in black spruce. Pages 65-72 *in* Demeritt, M.E. Jr. ed. Proc. 30th NE Forest Tree Improv. Conf., School of Forest Res., U. of Maine, Orono, July 22-24, 1986.

Boyle, T.J.B.; Morgenstern, E.K. 1987. Some aspects of the population structure of black spruce in central New Brunswick. Silv. Genet. 36:53-60.

Brand, D.G. 1987. Estimating the surface area of spruce and pine foliage from displaced volume and length. Can. J. Forest Res. 17:1305-1308.

Brand, D.G. 1988. Managing for successful reforestation programs. Pages 1-3 *in* Preprint Proc. Can. Pulp and Paper Assoc. Annual Conv.

Brand, D.G.; Janas, P.S. 1988. Growth and acclimation of planted white pine and white spruce seedlings in response to environmental conditions. Can. J. Forest Res. 18:320-329.

Burgess, D.M.; Chatarpaul, L.; Hendrickson, O.Q. 1987. Résultats préliminaires des essais de croissance au champ d'aulnes (*Alnus* spp.) inoculés ou non de *Frankia*. Rapp. d'inf. PI-X-67F.

Burgess, D.M.; Peterson, R.L. 1987. Development of *Alnus japonica* root nodules after inoculation with *Frankia* strain HFPArI3. Can. J. Bot. 65:1647-1657.

Burgess, D.M.; Peterson, R.L. 1987. Effect of nutrient conditions on root nodule development in *Alnus japonica*. Can. J. Bot. 65:1658-1670.

Chatarpaul, L. 1987. Biological and nutritional implications of harvesting biomass: a Central Ontario perspective. Pages 139-145 *in* Stiasny, Z.-Z. ed. Proc. Sixth Cdn. Bioenergy R&D Seminar, Richmond, B.C., Feb. 16-18, 1987.

Cheliak, W.M. 1987. Biotechnology in tree improvement. Pages 57-61 *in* Galloway, R.L. et al., eds. Proc. Symp. COJFRC O-P-15, Primeval improvement: the new forestry age.

Cheliak, W.M.; Yeh, F.C.H.; Pitel, J.A. 1987. Use of electrophoresis in tree improvement programs. For. Chron. 63:89-96.

Cheliak, W.M.; Yapa, A.C. 1988. Molecular genetics of forest trees. Inf. Rep. PI-X-80.

Coleman, M.N.; Nieman, T.C.; Boyle, T.J.B. 1987. Croissance, survie et forme de la tige, à 22 ans, d'épinette de Norvège soumises à un test de descendance. Rapp. d'inf. PI-X-73F.

Coleman, M.N.; Nieman, T.C.; Boyle, T.J.B. 1987. Growth, survival, and stem form of a 22-year-old Norway spruce progeny test. Inf. Rep. PI-X-73.

Daffern, J.G.; Poland, J.S.; Van Loon, G.W. 1987. Nutrient cycling and biomass distribution in IK plantations of hybrid poplar. Pages 129-133 *in* Stiasny, Z.-Z. ed. Proc. Sixth Cdn. Bioenergy R&D Seminar, Richmond, B.C., Feb. 16-18, 1987.

Flannigan, M.D.; Harrington, J.B. 1987. A study of the relationship of meteorological variables to monthly provincial area burned by wildfire in Canada 1953-80. Pages 229-234 *in* Preprint vol., Ninth Conf. Fire and Forest Meteorol., San Diego, Ca., April 21-24, 1987.

Fogal, W.H.; Mittal, R.K.; Thurston, G.S. 1987. Production et évaluation de *Beauveria bassiana* pour la lutte contre les insectes s'attaquant aux cônes et aux semences de l'épinette blanche. Rapp. d'inf. PI-X-69F.

Gillis, M. 1988. Gaps in Canada's forest inventory. PI-X-78.

Harrington, J.B. 1987. Climatic change: a review of causes. Can. J. Forest Res. 17:1313-1339.

Harrington, J.B.; Flannigan, M.D. 1987. Drought persistence at forested Canadian stations. Pages 204-206 *in* Preprint vol., Ninth Conf. Fire and Forest Meteorol., San Diego, Ca., April 21-24, 1987.

Hendrickson, O.Q. 1987. Winter branch nutrients in northern conifers and hardwoods. Forest Sci. 33:1068-1074.

Hendrickson, O.Q.; Burgess, D.M.; Chatarpaul, L. 1987. Biomass and nutrients in Great Lakes – St. Lawrence forest species: implications for whole-tree and conventional harvest. Can. J. Forest Res. 17:210-218.

Howe, J.L.; Poland, J.S.; Van Loon, G.W. 1987. Nutrient cycling and biomass distribution in 35K energy plantations of hybrid poplar. Pages 134-138 *in* Stiasny, Z.-Z. ed. Proc. Sixth Cdn. Bioenergy R&D Seminar, Richmond, B.C., Feb. 16-18, 1987.

Hurly, T.A.; Yeatman, C.W.; Robertson, R.J. 1987. Maturity and viability of seed from squirrel-cut pine cones. For. Chron. 63:268-271.

Institut forestier national de Petawawa. 1987. Realisations récentes à Petawawa. Mai 1987.

Institut forestier national de Petawawa. 1987. Revue de programme 1985-1987.

Kimmins, J.P.; Scoullar, K.A. 1987. Simulation of the yield, the sustainability of yield, the economics and the energy efficiency of biomass production in forestry and agroforestry using the flexible, ecosystem management modelling framework FORCYTE 11. Pages 146-149 *in* Stiasny, Z.-Z. ed. Proc. Sixth Cdn. Bioenergy R&D Seminar, Richmond, B.C., Feb. 16-18, 1987.

Kourtz, P.H. 1987. Expert system dispatch of forest fire control resources. AI Applications 1:1-8.

Kourtz, P.H. 1987. The need for improved forest fire detection. For. Chron. 63:272-277.

Larocque, G.; Marshall, P.L. 1988. Growth and yield of spruce in the inland mountain west: a literature review. Pages 192-196 *in* Schmidt, W.C. compiler, USDA Forest Serv. Gen. Tech. Rep. INT-243.

Larocque, G.; Marshall, P.L. 1988. Improving single-tree distance-dependent growth models. Pages 94-101 *in* Ek, A.R., et al., eds. Proc. IUFRO Conf., Minneapolis, Minn. USDA Forest Serv. Gen. Tech. Rep. NC-120.

Leckie, D.G. 1987. Factors affecting defoliation assessment using airborne multispectral scanner data. Photogram. Eng. Remote Sensing 53:1665-1674.

Magnussen, S.; Yeatman, C.W. 1987. Adjusting for inter-row competition in a jack pine provenance trial. Silv. Genet. 36:206-214.

Magnussen, S.; Yeatman, C.W. 1987. Early testing of jack pine. I. Phenotypic response to spacing. Can. J. Forest Res. 17:453-459.

Magnussen, S.; Yeatman, C.W. 1987. Early testing of jack pine. II. Variance and repeatability of stem and branch characters. Can. J. Forest Res. 17:460-465.

Magnussen, S.; Yeatman, C.W. 1987. Four years height growth of 25 jack pine (*Pinus banksiana* Lamb.) families in an accelerated nursery trial. Pages 47-64 *in* Demeritt, M.E. Jr., ed. Proc. 30th NE Forest Tree Improv. Conf., School of Forest Res., U. of Maine, Orono, July 22-24, 1986.

Mittal, R.K.; Singh, P.; Wang, B.S.P. 1987. Botrytis: a hazard to reforestation. Eur. J. Forest Path. 17:369-384.

Mittal, R.K.; Wang, B.S.P. 1987. Fungi associated with seeds of eastern white pine and white spruce during cone processing and seed extraction. Can. J. Forest Res. 17:1026-1034.

Mittal, R.K.; Wang, B.S.P.; Harmsworth, D. 1987. Effects of extended prechilling on laboratory germination and fungal infection in seeds of white spruce and eastern white pine. Tree Planters' Notes 38:6-9.

Monty, J. 1987. What do cells have to do with forest resource statistics? For. Chron. 63:20-22.

Murray, W.G. 1987. Emploi de bombardiers à eau et d'hélicoptères-citernes au Canada de 1978 à 1984. Rapp. d'inf. PI-X-68F.

Nietmann, K. 1987. Catalogue of Canadian forest inventory publications and manuals/Catalogue des manuels et publications de l'inventaire des forêts du Canada. Inf. Rep./Rapp. d'inf. PI-X-76E/F.

Newnham, R.M. 1987. FIRFOR – A simple forest management model. Inf. Rep. PI-X-72.

Newnham, R.M. 1987. FIRFOR – un modèle simple pour l'aménagement forestier. Rapp. d'inf. PI-X-72F.

Newnham, R.M. 1988. A modification of the Ek-Payandeh nonlinear regression model for site index curves. Can. J. Forest Res. 18:115-120.

Péch, Gy. 1987. Moisture code and fire spread index for reindeer lichen. Pages 80-82 *in* Proc. Ninth Conf. Fire and Forest Meteorol., San Diego, Ca., April 21-24, 1987.

Périnet, P.; Tremblay, F.M. 1987. Commercial micropropagation of five *Alnus* species. New Forests 3:225-230.

Périnet, P.; Tremblay, F.M.; Filion, C. 1987. Commercial micropropagation of five *Alnus* species. Acta Horticulturae 212:511.

Petawawa National Forestry Institute. 1987. Program Review 1985-1987.

Petawawa National Forestry Institute. 1987. Recent Achievements at Petawawa. May 1987.

Petawawa National Forestry Institute. 1988. Recent Achievements at Petawawa. March 1988.

Pitel, J.A.; Cheliak, W.M.; Barrett, J. 1987. Inheritance of allozymes in a black spruce diallel cross. Silv. Genet. 36:149-153.

Pitel, J.A.; Cheliak, W.M. 1988. Metabolism of enzymes with imbibition and germination of seeds of jack pine (*Pinus banksiana*). Can. J. Bot. 66:542-547.

Pitel, J.A.; Wang, B.S.P. 1988. Improving germination of basswood (*Tilia americana* L.) seeds with gibberellic acid. Seed Sci. Technol. 16:273-280.

Power, J.M. 1987. FIDSINFOBASE – Système d'information sur le relevé des insectes et des maladies des arbres. Rapp. d'inf. PI-X-65F.

Power, J.M.; Williams, D.H. 1988. A national Geographic Information System for the Forest Insect and Disease Survey – requirements and selection. Inf. Rep. PI-X-75.

Power, J.M.; Williams, D.H. 1988. Qualités requises et sélection d'un système d'information géographique national pour le Relevé des insectes et des maladies des arbres. Rapp. d'inf. PI-X-75F.

Schoen, D.J.; Cheliak, W.M. 1987. Genetics of the polycross. 2. Male fertility variation in Norway spruce, *Picea abies* (L.) Karst. Theor. Appl. Genet. 74:554-559.

Stocks, B.J.; Flannigan, M.D. 1987. Analysis of the behaviour and associated weather for a 1986 northwestern Ontario wildfire: Red Lake #7. Pages 94-100 *in* Preprint vol., Ninth Conf. Fire and Forest Meteorol., San Diego, Ca., April 21-24, 1987.

Todd, B.; Cai Denglin; Leckie, D.G. 1987. Production of enhanced Landsat imagery for forest fire fuel type mapping of northeastern China. Pages 225-237 *in* Proc. Beijing Intl. Symp. Remote Sensing, Beijing, China, Nov. 18-22, 1986.

Van Wagner, C.E. 1987. A moisture content model for medium-sized logging slash. Pages 34-40 *in* Proc. Ninth Conf. Fire and Forest Meteorol., San Diego, Ca., April 21-24, 1987.

Van Wagner, C.E. 1987. Forest Fire Research – hindsight and foresight. Pages 115-120 in USDA Forest Serv. Pacific SW Forest and Range Exp. Stn., Berkeley, Ca. Gen. Tech. Rep. PSW-101.

Wang, B.S.P. 1987. The beneficial effects of stratification on tree seed germination. Pages 56-75 *in* Proc. Nurserymen's Meeting, Dryden, Ont., June 15-19, 1987. Ont. Min. Nat. Res.

Wang, B.S.P. 1988. Review of new developments in tree seed. Seed Sci. Technol. 16:215-225.

Weber, M.G. 1987. Decomposition, litterfall, and forest floor nutrient dynamics in relation to fire in eastern Ontario jack pine ecosystems. Can J. Forest Res. 17:1496-1506.

Weber, M.G.; Monte Hummel; Van Wagner, C.E. 1987. Selected parameters of fire behaviour and *Pinus banksiana* Lamb. regeneration in eastern Ontario. For. Chron. :340-346.

Yapa, A.C.; Mitchell, M.H. 1987. Bibliography/Liste des publications pour les années 1979-1985. Inf. Rep./Rapp. d'inf. PI-X-70E/F.

ORGANIZATION AND PROJECT STAFF LISTING
1987-1988

Director	F.C. Pollett B.Sc., B.A., M.Sc., Ph.D., n.d.c. Secretary: J. Moncion
Program Directors	J.D. Walker B.Sc. Hons., M.F. (until May 29, 1987) G. Murray R.P.F., B.Sc.F., M.Sc., Ph.D. A.B. Case B.Sc.F., M.Sc.F. Secretary: A. McDonald (Supervisor) A. Hammond (Registry)
Information Services (Project PI-22)	D. Lemkay (Project Leader)
Editing and Publications Services (Project PI-24)	A.C. Yapa B.Sc. Hons., B.A. (Project Leader) B.A. Ballantyne B.A., B.Ed. E.F. Andersen
Personnel Officer (Project PI-70)	M. Pattison B.A. Clerk: F.I. McCarthy
Financial Services	S. Rice (Finance Officer) P. Swan L. Johnston A. Miller L. Dequire
Forest Resource Officer	W.R. Clark B.Sc.F.

PROJECTS

FOREST MANAGEMENT SYSTEMS

Program Director	J.D. Walker B.Sc. Hons., M.F. (until May 29, 1987) Position vacant
Fire Behavior and Effects (Project PI-4)	C.E. Van Wagner B. Eng., B.Sc.F. (Project Leader) M.G. Weber B.Sc.F., M.Sc., Ph.D. M.D. Flannigan B.Sc. Hons., M.S. J.W. Bell P.J. Litwin
Forest Fire Management Systems (Project PI-6)	P.H. Kourtz B.Sc.F., M.Sc., Ph.D. (Project Leader) B.E. Mroske B.Sc. J.B. Todd B.Sc.F. B.G. Rossen
Fire Suppression Systems (Project PI-7)	E. Stechishen M.Sc.F. (Project Leader) G. Péch B.Sc.F., M.F., M.Sc., M.Ph., Dip. For. Eng. F. Bouillon M. Hobbs W.G. Murray

Silviculture and Forest Productivity (Project PI-12)	D.G. Brand R.P.F., B.Sc.F., Ph.D. (Project Leader) P.S. Janas B.Sc.F. (until October 30, 1987) D.J. McGuire C. Robinson
Digital Remote Sensing (Project PI-16)	D.G. Leckie M.Sc., Ph.D. (Project Leader) A. Dombrowski B.ès.Sc., M.Sc. F. Gougeon M.A. Sc., Ph.D. S. Yatabe B.Sc. Hons., M.Sc.
Forest Management Modelling (Project PI-19)	R.M. Newnham B.Sc., M.F., Ph.D. (Project Leader) I.S. Alemdag For. Eng., M.F., Ph.D. G. Larocque B.Sc.A., M.ès.Sc. (on study leave) T.G.E. Moore B.Sc.F., M.Sc.
TECHNOLOGY TRANSFER AND OPERATIONS	
Program Director	A.B. Case B.Sc.F., M.Sc.F.
Fire Equipment, Products, and Methods - Development, Standards, and Evaluation (Project PI-5)	G.S. Ramsey (Project Leader) D.G. Higgins
Special Projects and Technology Transfer (Project PI-13)	D.J. Stewart R.P.F., B.Sc.F. (Project Leader)
Public Awareness (Project PI-14)	J.J. Williams (Project Leader) R. Davies B.Sc.F., M.Sc.F. J. Vaillancourt
Library Services (Project PI-15)	M. Mitchell B.A.Sc., M.L.S. (Project Leader) C. Penson
FIDS Technology Development (Project PI-20)	M. Power B.Sc.F. (Project Leader) L. O'Brien B.Sc. Hons. J.A. Edwards B.Sc.F.
Petawawa Research Forest Forest Management (Project PI-21)	J. Monty R.P.F., B.Sc.F. (Forest Estate Manager) K. Morrier (Manager, Forest Operations) C.R.C. Farr B.A. Mayo G.J. Yakabuskie (Manager, Field Services) D.A. Babinski N. Childs H.J. Clouthier J.C. Germaine E. Grieve L. Malone E. Paquette D.J. Turcotte O.M. Zohr

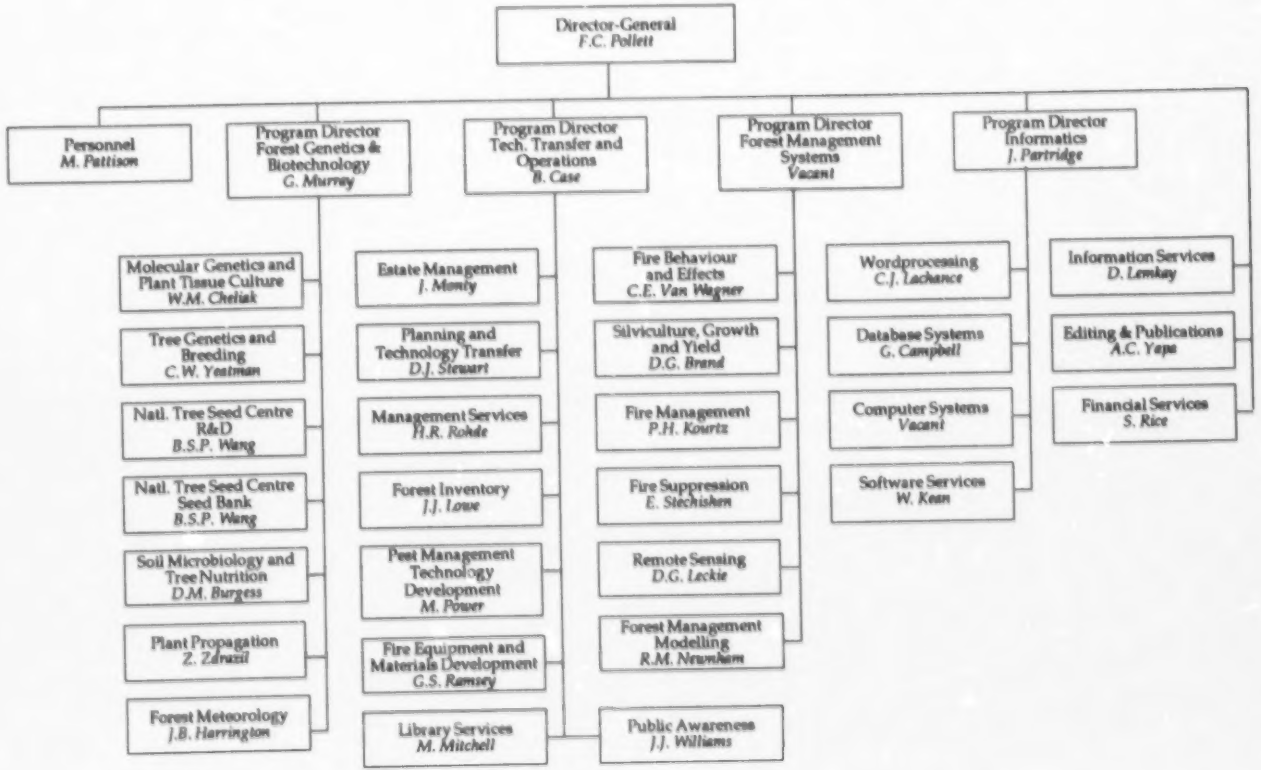
Forest Inventory (Project PI-54)	J.J. Lowe M.A., M.Sc.F. (Project Leader) M. Gillis B.Sc.F., B.A. S. Gray B.Sc. Hons. B.D. Haddon R.P.F., B.Sc.F. K. Nietmann B.Sc.F. G. Griffith M. Marsan
Management Services (Project PI-31)	H.R. Rohde (Administrative Officer) W.W. Levasseur (Contracts Officer) T. Kasaboski (Materiel Management) D. James J. Patterson S. Lamontagne (Senior Stationary Engineer) D.C. Houde S. O'Reilly W. Rodd C.E. Wilson B. Wyatt (Construction Foreman) K. Griffiths (Mechanic Supervisor) J. Davis R. Gohr

FOREST GENETICS AND BIOTECHNOLOGY

Program Director	G. Murray R.P.F., B.Sc.F., M.Sc., Ph.D.
Forest Meteorology (Project PI-8)	J.B. Harrington B.A., M.Sc., Ph.D. (Project Leader)
Tree Genetics and Breeding (Project PI-9)	C.W. Yeatman R.P.F., Dip. For., B.Sc.F., M.F., Ph.D. (Project Leader) T.J.B. Boyle B.Sc. Hons., Ph.D. S. Magnussen cand. silv., Ph.D. P. Copis B.Sc. T.G. Nieman B.Sc. D.D. Hoelke S. Kranz W.H. Selkirk J.R. Veen
National Tree Seed Centre, Research and Development (Project PI-10)	B.S.P. Wang B.Sc.F., M.F. (Project Leader) W.H. Fogal M.A., Ph.D. H.O. Schooley B.Sc.F., M.Sc. M.L. Anderson S. Lopushanski G. Scheer
Soil Microbiology and Tree Nutrition (Project PI-11)	L. Chatarpaul M.S., Ph.D. (Project Leader until November 12, 1987) D.M. Burgess B.Sc.F., Ph.D. (Project Leader from November 12, 1987) O.Q. Hendrickson M.Sc., Ph.D. O.L. Clark I.R. Miller R.D. Selby P. Chakravarty M.Sc., Ph.D. (Visiting Fellow) P. Subramaniam M.Sc., Ph.D. (Visiting Fellow)

National Tree Seed Centre, Seed Bank and Services (Project PI-17)	B.S.P. Wang B.Sc.F., M.F. (Project Leader) B. Kelley B.Sc. E. Gilchrist
Molecular Genetics and Plant Tissue Culture (Project PI-18)	W.M. Cheliak B.Sc.F., M.Sc., Ph.D. (Project Leader) F.M. Tremblay M.A.Sc., Ph.D. K. Klimaszewska M.Sc., Ph.D. J. Pitel B.Sc. P. Périnet B.Sc.A., M.Sc. (Visiting Fellow until May 1988) J. Kenny B.Sc., M.Sc. L. Deverno B.Sc. Hons. J.R. Lavereau
Plant Propagation (Project PI-60)	Z. Zdrazil (Project Leader) B. Corbett S. Brand E. Yakabuskie (Retired January 29, 1988)
INFORMATICS	
Program Director	J. Partridge B.Sc.
Wordprocessing (Project PI-41)	C.J. Lachance (Supervisor) S. Moreau
Database Systems (Project PI-42)	G. Campbell
Computer Systems (Project PI-43)	D. Dilabbio (Project Leader until January 8, 1988) W. Harris D. McKenna L. Roy E. Trottier D. St. Jules
Software Services (Project PI-44)	W. Kean (Project Leader) T. Bradley B.A. E. Leskie

PNFI ORGANIZATION CHART 1988



CANADIAN FORESTRY SERVICE ORGANIZATIONAL PLAN

Associate Deputy Minister
Assistant Deputy Minister (Forestry Operations)
Director Communications Branch
Director-General Finance & Administration Directorate
Director Executive Services
Manager Personnel
Assistant Deputy Minister (Forestry Policy)
Regional Director-General Pacific and Yukon Region
Regional Director-General Western and Northern Region
Regional Director-General Quebec Region
Regional Director-General Ontario Region
Regional Director-General Maritimes Region
Regional Director-General Newfoundland and Labrador Region
Director-General Forest Science Directorate
Director-General Forestry Development Directorate
Director-General Policy, Planning & Economics Directorate
Director-General, Technology and Industry Relations Directorate
Director-General Forest Pest Management Institute
Director-General Petawawa National Forestry Institute